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(54) Title: ANALYSIS AND SYNTHESIS OF RHYTHM

(57) Abstract

A rhythm analyser comprises input means (2), a low-pass filter bank (7) including a plurality of Gaussian-type low-pass filters each having differing cut-off frequencies, differentiating means (8) for producing a plurality of derivative signals, detection means (9) for detecting a substantially zero value in at least one of the derivative signals and for producing a zero crossing signal, storage means (10, 11), and processing means to record structural information in the storage means (10, 11) relating to the zero crossing signal comprising at least one of, the position in time of the zero crossing signal, the identity of the low-pass filter which produced the filtered signal, or the energy of the zero crossing signal. A corresponding system for synthesising musical rhythmic expression comprises synthesis means (116) for receiving structural information and for generating synthesis signals from the structural information.

ANALYSIS AND SYNTHESIS OF RHYTHM

This invention relates to a rhythm analyser for analysing rhythm and to a rhythmic expression synthesiser for 5 synthesising rhythmic expression, particularly though not exclusively for use with signals representing a musical performance.

In several fields of study it is useful to be able to 10 consistently and accurately analyse the rhythm of a sound. The sound may for instance be a musical or poetic performance in which case the analysis yields information about methods of performance and the way in which the performance is segmented by the performer. In other fields 15 such as the analysis of birdsong and insect chirps, the analysis is an aid to classification and recognition of the sound. In a slightly different field, the analysis of rhythm may be useful in analysing electro-myographic signals associated with muscular movements.
20

For example, it is known that temporal and dynamic variations in a performance (which variations constitute an expressive signal) contain significant information about the intended structure and interpretation provided by the 25 performer. The structure of the music may then be represented as a hierarchical grouping of events such as notes and phrases, in a tree structure.

A few systems exist which attempt to recover rhythmic 30 structure from a performed sequence of music. One such system employs a computer program based on a grammar, which takes input values from a musical keyboard and groups musical notes according to their rhythmic structure. Another system uses a neural network approach to the same 35 problem. A further system employs a signal processing appr ach based on a model of the auditory system and is thus abl to analyse music dir ctly from sound rather than from

electrical input from a keyboard or other instrument. This latter system runs in real-time and is able to track a live performance.

5   Whilst each of these systems is able to recover low-level rhythmic structure to varying degrees of success, they do not address the problem of higher level structure above the level of the musical bar, i.e. structures such as phrases, sections or even movements. Furthermore, none of these
10   systems is able to recover fully the expressive information contained in a musical performance.

Whilst systems exist for synthesising expressive performances, none employ a realistic representation of
15   structure and thus considerable adjustment by hand is required to produce a realistic performance.

According to a first aspect of the invention, a rhythm analyser comprises input means for receiving an input signal representing the energy of a time-varying electrical signal and for generating an output signal, a
5   low-pass filter bank including a plurality of Gaussian-type low-pass filters having differing cut-off frequencies each for filtering the output signal to produce a plurality of respective filtered signals, differentiating means for receiving the filtered signals
10   and for producing a plurality of derivative signals representing at least the first derivative of each filtered signal, detection means for detecting a substantially zero value in at least one of the derivative signals and for producing a zero crossing
15   signal corresponding to the derivative signal having the substantially zero value, storage means, and processing means, the processing means being operable, upon receipt of the zero crossing signal, to record structural information in the storage means relating to the zero
20   crossing signal comprising, at least one of, the position

in time of the part of the input signal which corresponds
to the zero crossing signal, the identity of the low-pass
filter which produced the filtered signal which
corresponds to the zero crossing signal, and the energy
5   of the part of the input signal which corresponds to the
zero crossing signal.

According to a second aspect of the invention, a method
of analysing rhythm comprises filtering a signal
10 representing the energy of a time varying electrical
signal through a low-pass filter bank comprising a
plurality of Gaussian-type low-pass filters having
differing cut-off frequencies to produce a plurality of
respective filtered signals, differentiating the filtered
15 signals to produce a plurality of derivative signals
representing at least the first derivative of each
filtered signal, detecting a substantially zero value in
at least one of the derivative signals and producing a
zero crossing signal corresponding to the derivative
20 signal having the substantially zero value, and upon
receipt of the zero crossing signal, recording structural
information relating to the zero crossing signal
comprising, at least one of, the position in time of the
part of the input signal which corresponds to the zero
25 crossing signal, the identity of the low-pass filter
which produced the filtered signal which corresponds to
the zero crossing signal, and the energy of the part of
the input signal which corresponds to the zero crossing
signal.
30
The range of time constants for the low pass filters is
preferably between 100 seconds and 20ms. This range is
particularly useful for the analysis of musical rhythmic
expression.
35
By preferably using low-pass filters having infinite
impulse responses, the tool may be made more useful in

psychological studies, since these types of filters are more akin to natural filter processes than those having finite impulse responses.

5 Preferably, the input signal is sampled and the low-pass filters are digital filters. This permits much greater flexibility in the operating parameters of the analyser particularly in relation to the number, type and spacing of the filters in the filter bank.

10

Given a form of expressive representation, or having generated structural information, and perhaps stored it, the information may be used to synthesise musical rhythmic expression.

15

According to a third aspect of the invention, a system for synthesising musical rhythmic expression comprises synthesis means for receiving structural information and for generating synthesis signals from the structural

20 information, a pulse generator coupled to the synthesis means, for generating a pulse signal from the synthesis signals, and a filter means coupled to the pulse generator, comprising a plurality of Gaussian-type filters, for generating an expressive movement signal by

25 filtering the pulse signal and summing the outputs of the filters.

The expressive movement signal is preferably fed back to the synthesis means to be used, in conjunction with

30 built-in information related to typical tempo and dynamic variations used by a performer for particular structures, to provide a modulation output. The modulation output is preferably used to modulate the automatic performance of an instrument which might for example, be a MIDI-type

35 instrument.

5

Preferably the structural information is a library store
of zero-crossing structures generated by the analysis
system.   It may instead be generated directly from a
score.   This score is preferably of the type used for
5 input to a MIDI-type instrument.   By combining the
modulation output feature and the direct structural
information generation feature, the synthesis system may
be used to read a score and to generate a fully automated
rhythmically expressive performance of the score with
10 little or no manual intervention.

According to a fourth aspect of the invention, a method
of analysing rhythm comprises taking a signal that has
been filtered through a Gaussian-type filter means and
15 differentiated, in order to extract rhythmic structural
information.

The invention will now be described by way of example,
with reference to the drawings in which:-
20

Figure 1 is a block diagram of a rhythm analyser in
accordance with the invention;

Figures 2(a) to 2(c) show a musical rhythmic cliche;
25

Figures 3(a) to 3(e) each show a zero-crossing structure
for the cliche of Figure 2;

Figure 4 shows an energy density spectrum (or surface)
30 for the cliche of Figure 2;

Figure 5 is a block diagram of a first embodiment of a
synthesis system in accordance with the invention; and

35 Figure 6 is a block diagram of a second embodiment of a
synthesis system in accordance with the invention.

A rhythm analyser in accordance with the invention may be
implemented in combination with a conventional computer
with some additional hardware and software. The
additional hardware and software requirements are
5   described below. The computer (not shown) may for
example, be an IBM compatible or Apple Macintosh (Trade
Mark) type computer. The computer may have some form of
graphical output device such as a printer or VDU, and a
storage device such as a disk drive or tape streamer.
10 Additionally it may have some form of user input device
such as a keyboard and/or a pointing device such as a
mouse.

Alternatively, the analyser described below may be
15 manufactured using entirely analogue components.

With reference to Figure 1, an analogue audio signal is
fed from an input device 1 into an input of an interface
card 2 installed in the computer. The input device 1 may
20 for example, be a tape cassette, compact disk player or
microphone.

The card 2, comprises a full-wave rectifier and analogue
multiplier 3, an anti-aliasing filter 4 and a 12 bit
25 analogue-to-digital convertor (ADC) 5. The rectification
circuit used in the rectifier 3 may be an active circuit
using two operational amplifiers and two signal diodes in
a conventional manner. The analogue multiplier is used
to square the audio input signal so that the output from
30 this stage is a measure of the energy density of the
input signal. The multiplication circuit may also
provide any amplification and/or buffering required by
the output of the input device 1.

35 The cut-off frequency of the low-pass anti-aliasing
filter is variable to allow the analyser to analyse
different frequencies. The cut-off frequency should be

at most half that of the sampling frequency of the ADC 5 and in practice, the cut-off frequency is kept below 20Hz with a sampling frequency in excess of 100Hz. The filter 4 may be a 5th-order, all-pole, maximally flat low-pass

5 filter implemented using an LTC1062 chip, in which case the cut-off frequency can be adjusted by altering the frequency of the clock signal supplied to the chip.

The sampling frequency of the ADC 5 is also variable and
10 should be adjusted according to the need to avoid aliasing of the input signal and the capability of the rest of the computer to accept the data output from the ADC 5.

15 The output from the ADC 5 comprises a series of values representing the instantaneous energy density of the input signal, and may be processed in real time and/or may be stored on a storage device such as disk storage 10, for later processing.
20
The main elements for processing the ADC output data are enclosed in box 6 in Figure 1 and comprise a digital low-pass filter bank 7, differentiation means 8 and detection means 9.   As mentioned above, although in this
25 embodiment, the elements in box 6 are implemented in software, they could instead be implemented in hardware.

The filter bank 7 comprises several Infinite Impulse Response (IIR) filters having a Gaussian-type response.
30 Since a perfect Gaussian response cannot practically be implemented, approximations must be used and these can be selected from Taylor, Laguerre or Bessel series approximations. The order of each filter is adjustable and a range of between first and ninth order is
35 acceptable in this application. The filter range is also adjustable i.e. the shortest and longest time constant in

the filter bank. Finally, the filter spacing is adjustable, in terms of the number of filters per octave.

The digital implementation of the filters may be derived
5 for example, by applying a bilinear transform to a suitable analogue filter design.

The output of each filter represents the energy density of each frequency range or channel and therefore taking
10 all channels, represents an energy density frequency spectrum as a function of time. The output from each channel is fed from the filter bank to the differentiating means 8.

15 The differentiating means 8 differentiates the output from each channel up to the nth derivative where n is variable. The differentiation of the filtered signal has the same effect as passing the filter through a band-pass bank with a Gaussian response and the analyser could be
20 implemented in that way.

The output from the differentiating means 8 is passed to the detection means 9.

25 A rhythmic interpretation of the input signal which in musical terms, can be described by metre and phrasing requires three kinds of information and the detection means is triggered under three conditions relating to these three types of zero crossing structure:
30

(i)   stress structure - a zero in the 1st order derivative in conjunction with a negative 2nd order derivative, in a particular channel at a particular time.

35 (ii) group structure - a zero in the 1st derivative in conjunction with a positive second derivative in a particular channel at a particular time.

(ii) **onset structure** - a negative-going zero crossing of the nth order derivative (typically n=2) for a particular channel at a particular time.

5   The analyser is, in signal processing terms, convolving a Gaussian type infinite impulse response with the signal energy $|x(t)|^2$ over a range of time constants $\{\tau|k=0\ldots N-1\}$ such that

$$S_G(t,f_k) = G(t,\tau_k) * |x(t)|^2 = \int_0^\infty G(t',\tau_k) |x(t-t')|^2 dt'$$

10 Where $S(t,f)$ is a windowed measure of the energy density spectrum, $G(t,\tau)$ is a Gaussian low-pass impulse response function, $f_k = 1/\tau_k$, t is time and τ is a time constant.

In the case of onset detection, the conditions

$$\frac{d^2}{dt^2}S_{G_2}(t,\tau_k) = 0$$

15

and

$$\frac{d}{dt}S_{G_2}(t,\tau_k) > 0$$

must be met and similar conditions as described above, must be met for the other two zero-crossing structures 20 (group and stress structures).

A musical rhythmic cliche is shown in Figure 2 and sample outputs from the analyser are shown in Figures 3(a) to 3(e), for that cliche. The loci of zero-25 crossings of the filter $d^2/dt^2 G_2(t, \tau_k)$ convolved with the signal energy from the sequence shown in Figure 2(d) is shown in Figure 3(a) which shows an onset structure. G_2 denotes a second-order Gaussian approximation. The time constants have a range 20ms-200ms. Figures 3(b) to 3(d)

show stress structures. In Figure 3(b), the loci of the zero crossings of the filter $d/dtG_3(t,\tau_k)$ convolved with the signal energy from the sequence shown in Figure 2(d) is shown. In Figure 3(c) the same sequence is shown with

5   a 3dB accent on e5 and in Figure 3(d) the same sequence is shown again with e5 doubled in length giving the musical effect of legato. G_3 is a third order Gaussian approximation and the time constants τ_k have the range 50ms-3000ms. Figure 3(e) shows a group zero crossing

10 structure for the cliche of Figure 2. This has separated the groups (P1 and P2 in Figure 2(a)) but for a short input signal such as this, it does not yield a great deal of information. The group structure will for example indicate the boundaries of a verse in poetry

15

When the detection means 9 is triggered, it records the time, channel, energy and type of trigger. This structural information relating to the zero crossing structures may be stored on the storage device 10 or may

20 be passed on to the output processor 11.

The storage device 10, can be used to store output data from the ADC 5 in the form of ASCII text files. Since the sampling rate is in most cases, not much more than

25 100Hz, it is feasible to store long samples. ASCII text files may also be used for storing information relating to the zero-crossing structures.

The output processor 11 is able to process three types of

30 display which may be output on a VDU, printer or other type of graphical display device.

The three types of display are:
(i) A display of the three types of structures 12 that

35   trigger the differentiating means. (These have been discuss d above in connection with Figures 2 and 3).

(ii) A display of the energy density spectrum 13 of the
input signal.

(iii) A display of analyser system parameters 14.

5   The three structures (or zero-crossing structures) are of
three kinds as discussed above. Each of these can be
displayed separately or in any combination. The
structures can be displayed as a 2D scatterplot of events
with time on the X-axis and either time-constant or
10 energy on the Y axis. A single event can be represented
by a single pixel. Alternatively , the 3D aspect (i.e.
time, time-constant and energy) of the zero crossing
structures can be represented using colour to represent
the energy of a particular event. In addition, any of
15 the displays may be annotated by the operator. This
feature may be used to label particular features of a
zero crossing structure.

The stress structure is used most often and resembles the
20 tree structures used in speech and musical analysis to
represent rhythm.

Typically, onset structures in music for example, have
short time constants of up to about 1 second whereas
25 stress and group structures have longer time constants.
For example to recover the group structure relating to
the movements of a symphony, time constants of the order
of the length of a movement are required i.e. 15 or 20
minutes. Using time constants longer than the duration
30 of the input signal will yield no additional information.
Since the range of time cⁿnstants displayed may be varied
separately for stress and group s uctures on one hand
and for onsets on the other, the s es of the plots may
vary. In this case the display may be divided into
35 separate "windows" which display simultaneously the
global and local aspects of the structures.

The energy density frequency spectrum can be plotted directly from the data output of the filter bank. This display is not restricted to the display only of zero-crossing triggers detected by the detection means 9.

5 With reference to Figure 4 which shows an energy density spectrum (or surface) for the cliche of Figure 2, the display resembles a "mountain range" with energy represented by the height of the range, decreasing time constant represented by the distance into the plot and

10 time moving from left to right. In this display, the valleys correspond to the segmentation or group structure and the peaks correspond to the stress structure.

The energy density spectrum may be scrolled in real-time

15 to give a dynamic representation which aids the intuitive understanding of the zero-crossing structure plots.

The sytem is controlled and directed using processing and user control means 15.

20

For each of the foregoing displays, the system parameters used to record and display the plot, may be simultaneously displayed.

25 The third display is that of the analyser parameters 14, These can be altered using a keyboard 16 and mouse. The parameters that may be varied by an operator of the analyser are either process control parameters 17a to 17e or data control parameters 18a to 18c.

30

The following process control parameters may be adjusted:
(a)   anti-aliasing low pass cut-off frequency (typically about 20Hz),
(b)   sampling rate (typically about 100Hz),
35 (c)   number of samples (sets duration of analysis, can be infinite for real time analysis with no storage of data), and

13

(d)   digital filter bank parameters

    (i)   ... <u>approximation type</u> (Bessel, Laguerre, Taylor, typically Taylor)

    (ii)   <u>approximation order</u> (typically 6th order for stress, 2nd order for onset)

    (iii)   <u>range</u> (typically 0.25s-30s for stress, 0.05s-0.5s for onset)

    (iv)   <u>filter spacing</u> (typically 12 per octave).

The following data control parameters may be adjusted:

(a)   **sample status flags,**

    (i)   <u>acquire only</u> - storage only, output filename requested.

    (ii)   <u>acquire and analyse</u> - storage and analysis, output filename requested.

    (iii)   <u>retrieve and analyse</u> - retrieve from storage and analyse, input filename requested.

(b)   **energy density display flags, and**

    (i)   <u>display enabled</u> - x and y scaling factors requested.

    (ii) <u>scroll/static</u> - type of display, scrolled or repeatedly overwritten in static form.

(c)   **zero-crossing structure display flags**

    (i)   <u>define combination of display types</u> - stress structure, group structure and/or onset structure.

A corresponding synthesis system operates to regenerate a rhythmically expressive performance and has two separate modes:-

(i)   Reconstructive Mode in which the envelope of an expressive signal can be reconstructed from its structural analysis which forms an input.

(ii) Modulation mode in which the output of the synthesis filter can be used to modulate a performance via a standard MIDI interface.

5   With reference to Figure 5 and 6, the synthesis system comprises:-

(a)   a means of representing and retrieving a stored structural information 114;

10

(b)   a synthesis algorithm 116 which in Figure 5 is the reverse of the analysis elements 6;

(c)   a multi-channel pulse generator 118; and

15

(d)   a multi-channel synthesis filter-bank 120.

In reconstructive mode (as shown in Figure 5), the structural information which forms the input to the
20 synthesis system have the same format as that generated by analysis system. The structures can be retrieved from a library. In reconstructive mode, the synthesis algorithm reconstructs the real-time properties of the structure from its compact coding and directs to each
25 channel a series of logic pulses of varying widths. The logic pulses trigger the pulse-generator which in turn provides impulses to the synthesis filter system which simulate the zero-crossings recorded by the analysis system. The synthesis filter bank mirrors the analysis
30 filter bank used to derive the structure information. The parameters of the synthesis filter-bank are the same as those used in the analysis filter bank when the structural information was recorded. The response of the synthesis filters are summed to produce a reconstructed
35 signal envelope.

With reference to Figure 6, the starting point in beat modulation mode is a score 122 of a piece of music i.e. a representation of the note values necessary to drive a MIDI interface 124.   From this the user derives a
5   normative structure 114b i.e. one which does not have real-time values, but relative durations. The terminal nodes of this structure correspond to beats in the score 122.

10   The system operates from this derived structure 114b in much the same way as in reconstructive mode. However, in this mode, the expressive movement is fed back via a feedback path 126 to the synthesis algorithm 116b. This algorithm differs from that used in reconstructive mode
15   in that it operates to modulate the tempo and dynamics of a modulated score 128 according to built-in "performance" rules which operate on the expressive movement signal. The modulated score 128 is output via the MIDI interface 124 to a MIDI instrument 126.   This system thereby
20   generates an automatic expressive performance from a musical score. The output from the MIDI instrument is also controlled by style parameters such as "global tempo".

CLAIMS

1. A rhythm analyser comprising:

input means for receiving an input signal representing the energy of a time-varying electrical signal and for generating an output signal,

a low-pass filter bank including a plurality of Gaussian-type low-pass filters having differing cut-off frequencies each for filtering the output signal to produce a plurality of respective filtered signals,

differentiating means for receiving the filtered signals and for producing a plurality of derivative signals representing at least the first derivative of each filtered signal,

detection means for detecting a substantially zero value in at least one of the derivative signals and for producing a zero crossing signal corresponding to the derivative signal having the substantially zero value,

storage means, and

processing means operable, upon receipt of the zero crossing signal, to record structural information in the storage means relating to the zero crossing signal comprising, at least one of: the position in time of the part of the input signal which corresponds to the zero crossing signal; the identity of the low-pass filter which produced the filtered signal which corresponds to the zero crossing signal; and the energy of the part of the input signal which corresponds to the zero crossing signal.
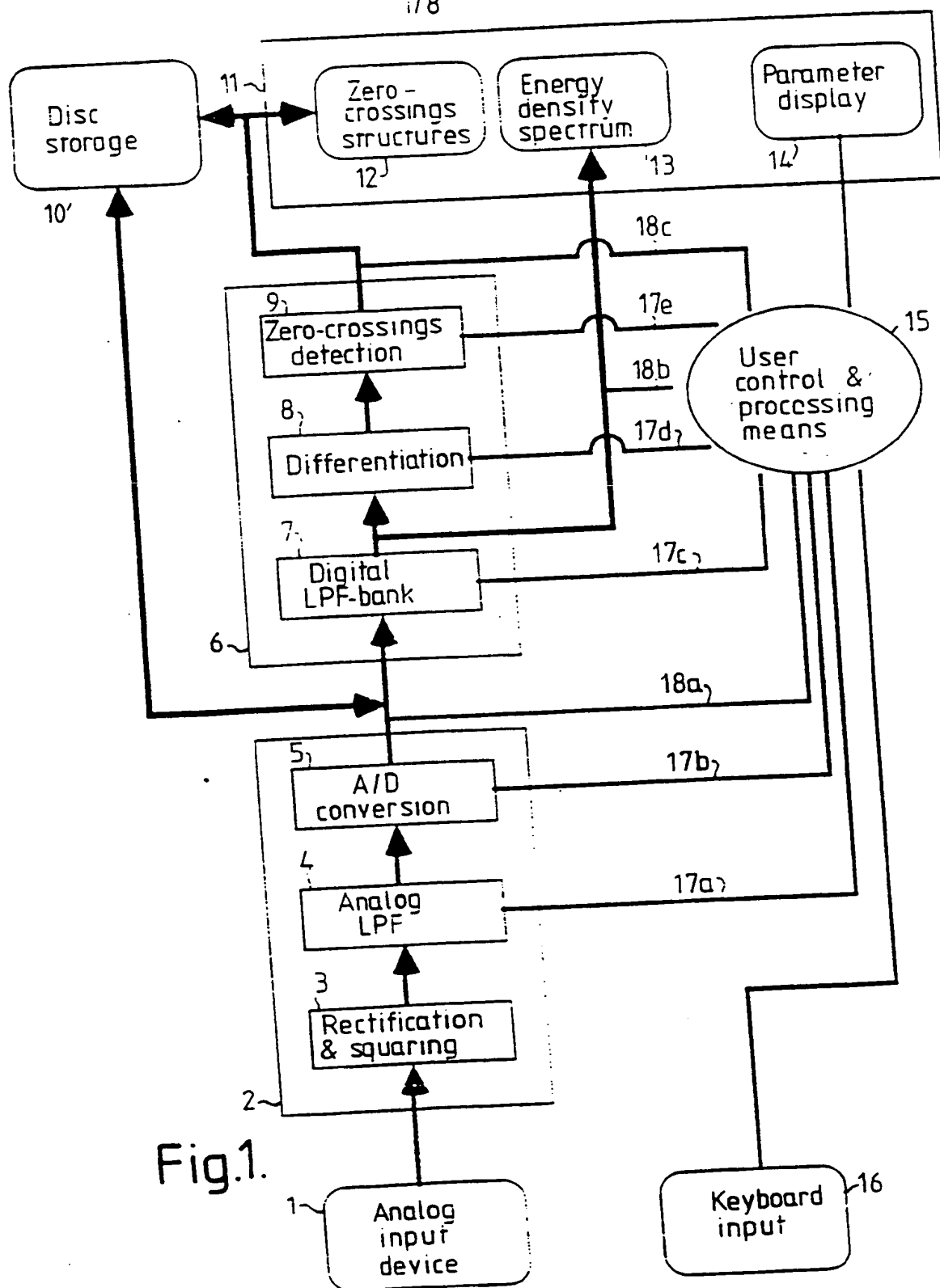
2. An analyser according to claim 1, wherein the low-pass filters have time constants in the range from 100 seconds to 20ms.

3.   An analyser according to any preceding claim, wherein each low-pass filter has an infinite impulse response.

5   4.   An analyser according to any preceding claim, wherein the time-varying electrical signal is an audio signal.

5.   An analyser according to any preceding claim,
10   wherein the detection means is operable to detect a stress structure by recognising the coincidence of a substantially zero value in the first order derivative and a negative second order derivative in the derivative signals associated with one of the
15   low-pass filters.

6.   An analyser according to any preceding claim, wherein the detection means is operable to detect a group structure by recognising the coincidence of a
20   substantially zero value in the first order derivative and a positive second order derivative in the derivative signals associated with one of the low-pass filters.

25   7.   An analyser according to any preceding claim, wherein the detection means is operable to detect an onset structure by recognising the coincidence of a substantially zero value in at least the second order derivative and a negative value in the next
30   highest order derivative in the derivative signals associated with one of the low-pass filters.

8.   An analyser according to claim 7, wherein the onset structure is detected by recognising a substantially
35   z ro value in the second order derivative.

9.   An analyser according to any of claims 5 to 8, wherein the processing means is operable to record the type of structure as part of the structural information.

10. An analyser according to any preceding claim, wherein the input means comprises an anti-aliasing filter and an ADC for sampling the input signal and wherein the low-pass filters are digital filters.

11. An analyser according to any preceding claim, wherein the storage means comprises any one of a computer disk, a computer memory, a VDU driver circuit, a chart recorder, a tape streamer and a printer.

12. A method of analysing rhythm comprising:
          filtering a signal representing the energy of a time varying electrical signal through a low-pass filter bank comprising a plurality of Gaussian-type low-pass filters having differing cut-off frequencies to produce a plurality of respective filtered signals,
          differentiating the filtered signals to produce a plurality of derivative signals representing at least the first derivative of each filtered signal,
          detecting a substantially zero value in at least one of the derivative signals and producing a zero crossing signal corresponding to the derivative signal having the substantially zero value, and
          upon receipt of the zero crossing signal, recording structural information relating to the zero crossing signal comprising, at least one of: the position in time of the part of the input signal which corr sponds to the zero crossing signal; the identity of the low-pass filter which produced the filtered signal which corresponds to the zero

crossing signal; and the energy of the part of the input signal which corresponds to the zero crossing signal.

5   13.   A method according to claim 12, comprising detecting a stress structure by recognising the coincidence of a substantially zero value in the first order derivative and a negative second order derivative in the derivative signals associated with one of the

10   low-pass filters.

14.   A method according to claim 12 or to claim 13, comprising detecting a group structure by recognising the coincidence of a substantially zero

15   value in the first order derivative and a positive second order derivative in the derivative signals associated with one of the low-pass filters.

15.   A method according to any of claims 12 to 14,

20   comprising detecting an onset structure by recognising the coincidence of a substantially zero value in at least the second order derivative and a negative value in the next highest order derivative in the derivative signals associated with one of the

25   low-pass filters.

16.   A method according to claim 15, wherein the onset structure is detected by recognising a substantially zero value in the second order derivative.

30
17.   A method according to any of claims 12 to 16 comprising recording the structural information on any one of a computer disk, a computer memory, a VDU driver circuit, a chart recorder, a tape streamer

35   and a printer.

18. A system for synthesising musical rhythmic expression comprising:

synthesis means for receiving structural information and for generating synthesis signals from the structural information,

a pulse generator coupled to the synthesis means, for generating a pulse signal from the synthesis signals, and

a filter means coupled to the pulse generator, comprising a plurality of Gaussian-type filters, for generating an expressive movement signal by filtering the pulse signal and summing the outputs of the filters.

Fig.1.
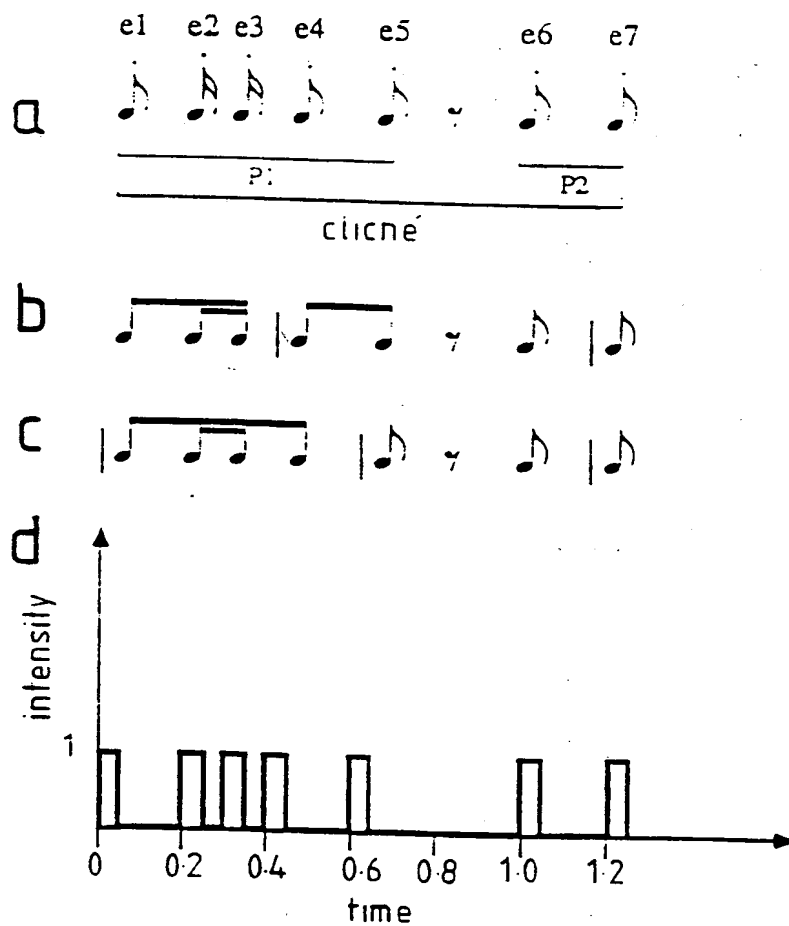
Fig.2.

Fig.3a.
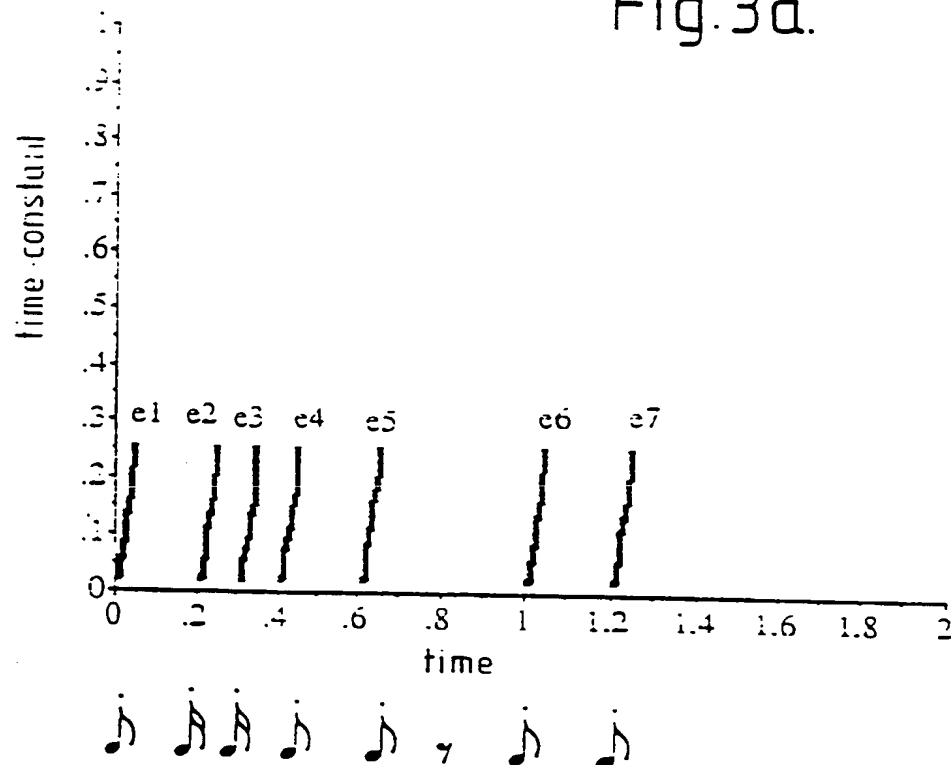
Fig.3b.
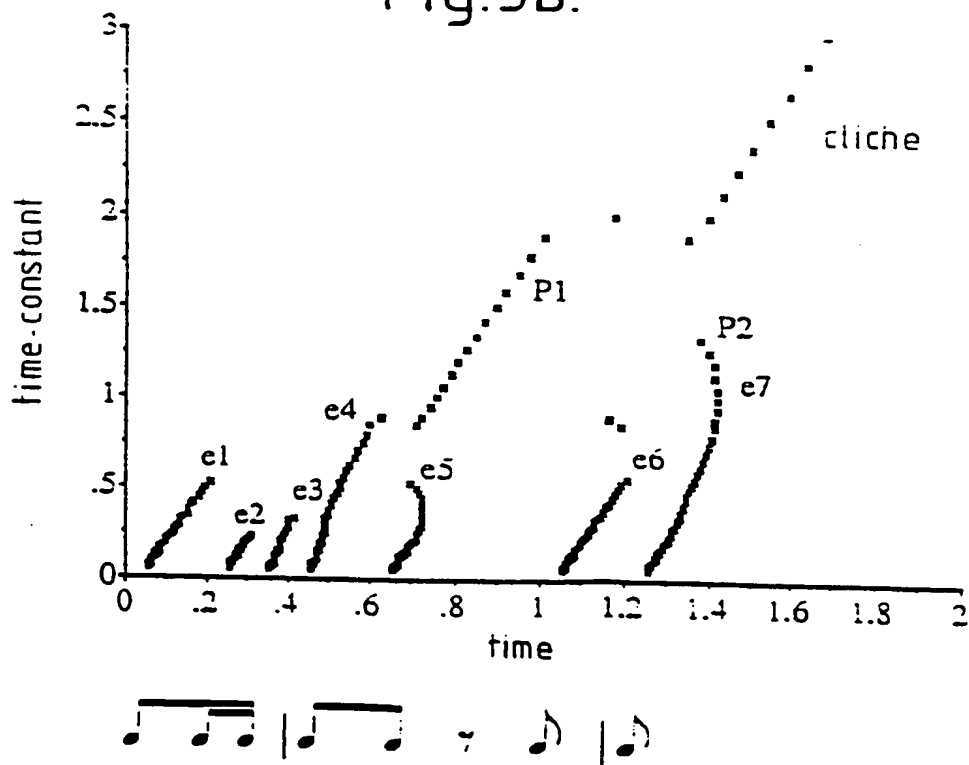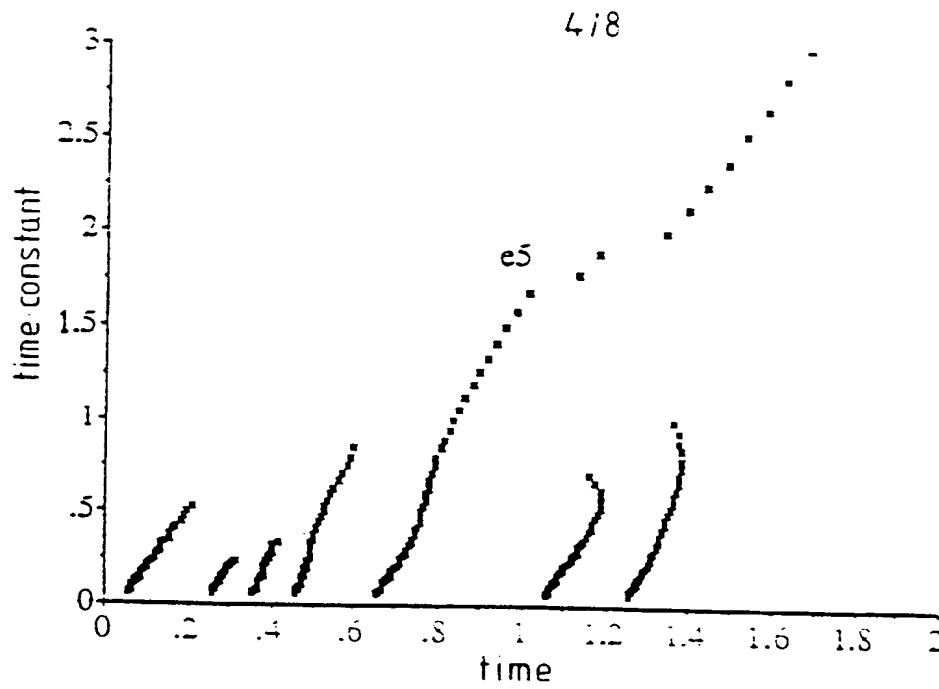
Fig.3c.
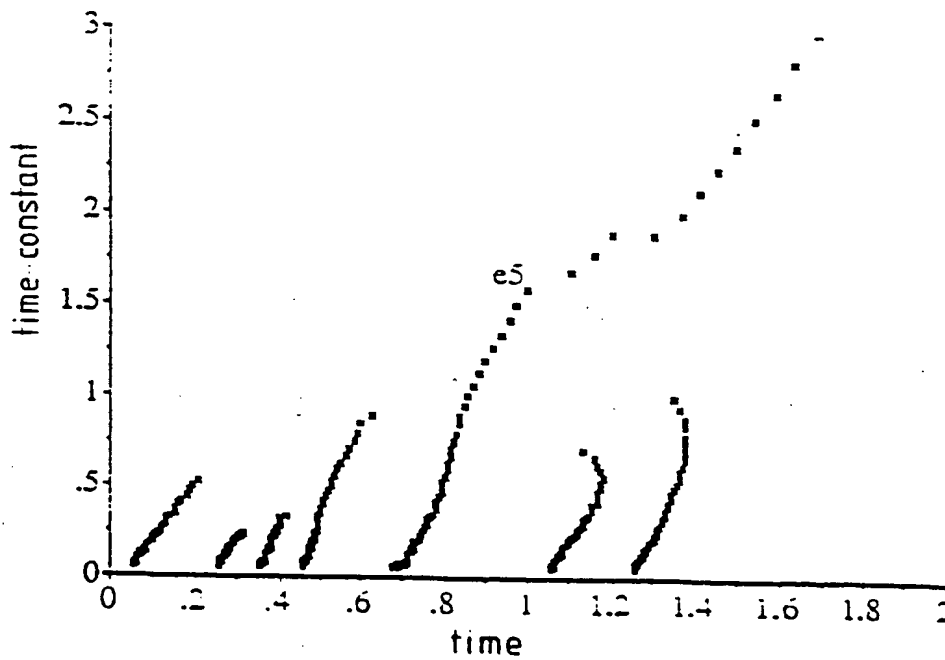
Fig.3d
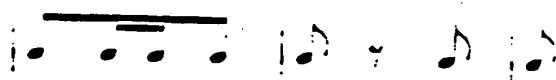
Fig.3e.
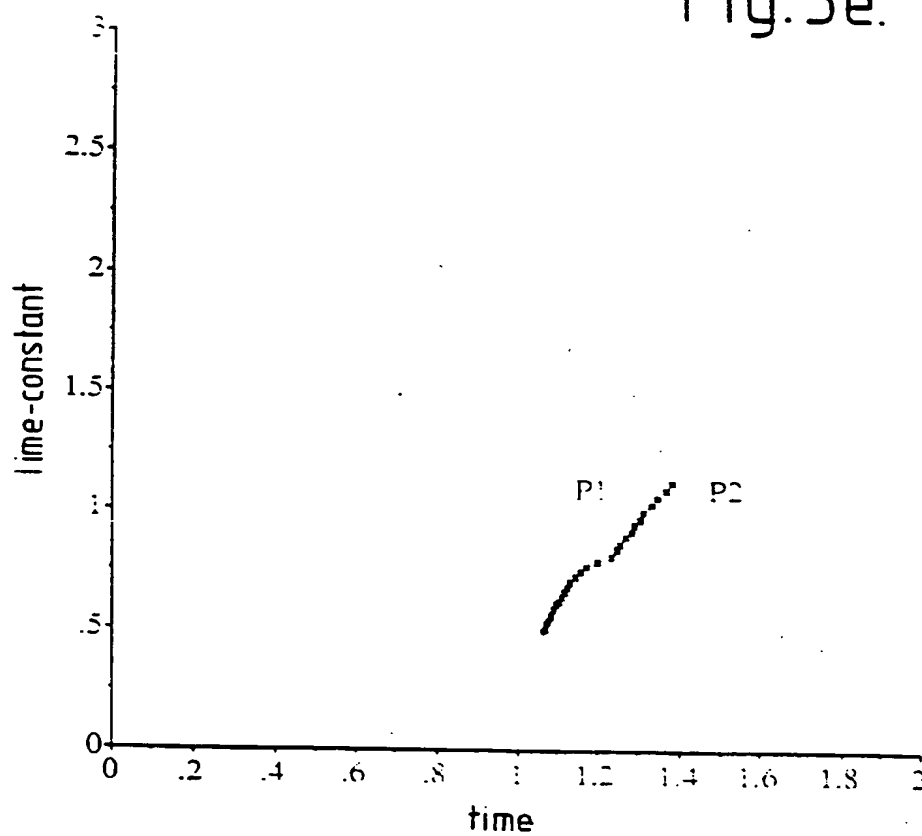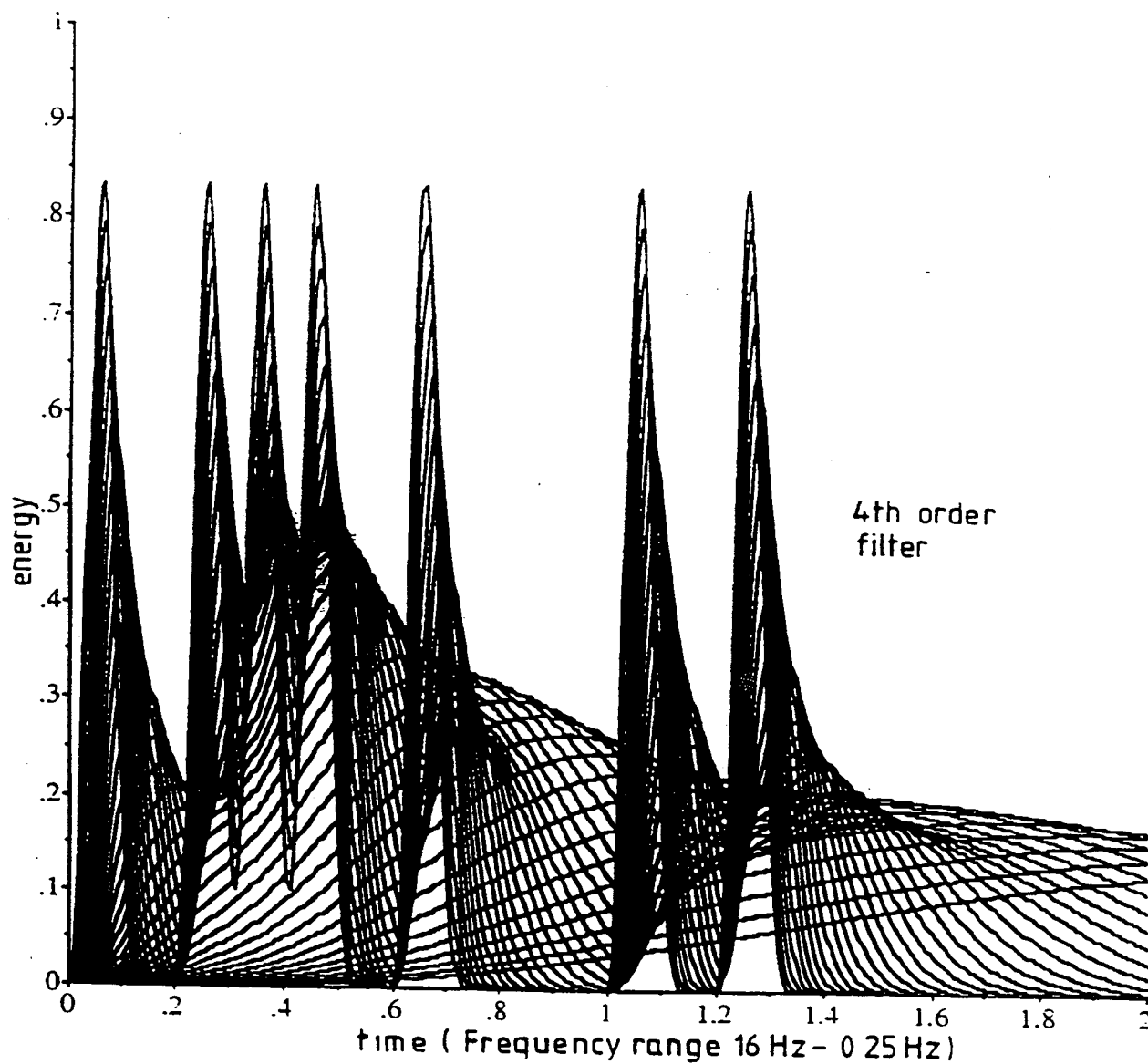
Fig. 4.

SYNTHESIS SYSTEM
(Reconstructive)
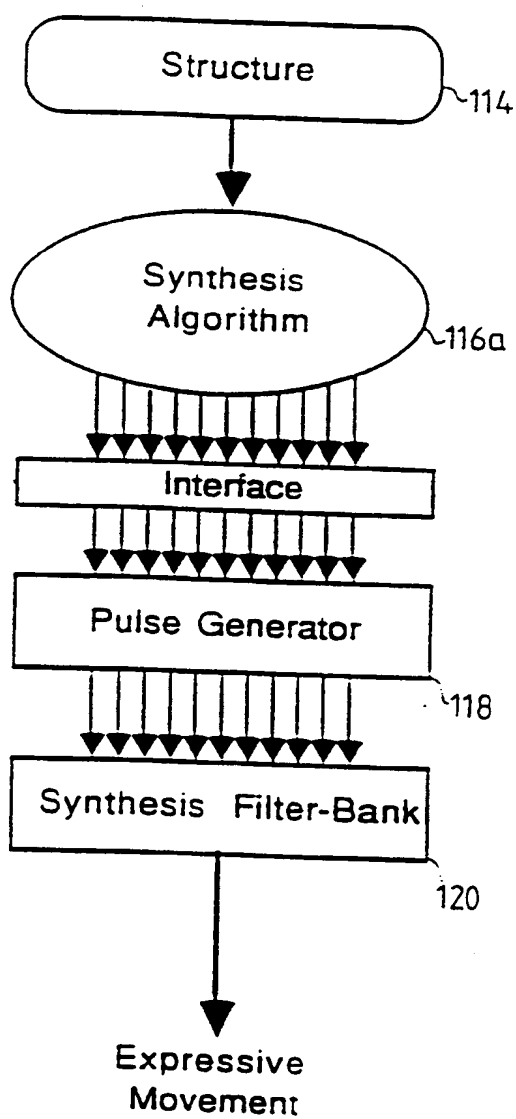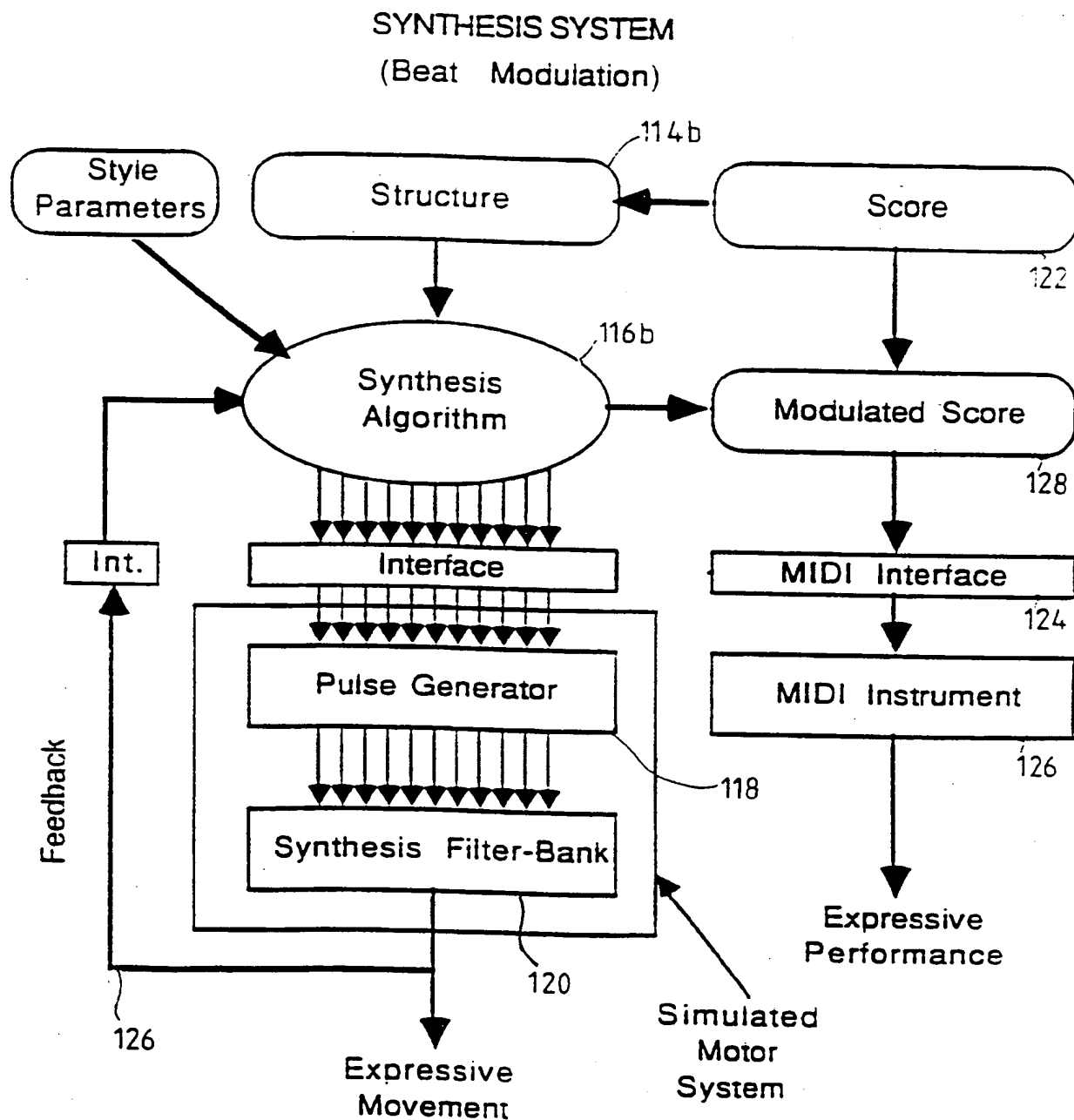
Structure ~114

Synthesis
Algorithm ~116a

Interface

Pulse Generator

~118

Synthesis Filter-Bank

120

Expressive
Movement

Fig.5.

SYNTHESIS SYSTEM

(Beat   Modulation)

Fig.6.

INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)⁶

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G10H1/40;   G10H1/12

II. FIELDS SEARCHED

Minimum Documentation Searched⁷	
Classification System	Classification Symbols
Int.Cl. 5	G10H

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched⁸

III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹

Category°	Citation of Document,¹¹ with indication, where appropriate, of the relevant passages¹²	Relevant to Claim No.¹³
A	US,A,4 354 412 (DEUTSCH) 19 October 1982 see column 1, line 51 - line 68; figure 1	1,12,18
A	GB,A,2 063 546 (TECHWISE INTERNATIONAL LTD) 3 June 1981 see page 1, line 18 - line 88; figure 1	1,12,18
A	US,A,4 276 802 (MIEDA) 7 July 1981 see column 1, line 66 - column 2, line 46; figures 1,3	1,12
A	US,A,4 939 471 (WERRBACH) 3 July 1990 see column 1, line 1 - line 54; figure 1	1,12

° Special categories of cited documents :¹⁰

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29 SEPTEMBER 1993	0 1. 10. 93
International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	PULLUARD R.J.P.

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

GB   9301183
SA   75514

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29/09/93

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4354412	19-10-82	JP-A- 57192995	27-11-82
GB-A-2063546	03-06-81	None	
US-A-4276802	07-07-81	JP-A- 54131921	13-10-79
US-A-4939471	03-07-90	None	

Docket # S&ZFH020501

Applic. #_____

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EPO FORM P0459

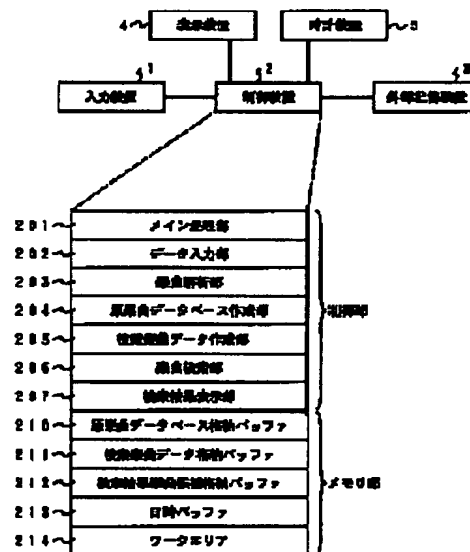For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

(54) **MUSIC RETRIEVAL DEVICE AND METHOD**

(57) Abstract:

PROBLEM TO BE SOLVED: To retrieve target music data on the basis of music information which is spoken by a human or played on a musical instrument.

SOLUTION: A music data base generation part 204 generates a source music data base consisting of music data including internal data, rhythm data, and text data and music information data consisting of information on numbers, composer's names, etc., by music in advance. When desired music to be retrieved is spoken or played on the musical instrument by a person, a retrieved music data generation part 205 analyzes its rhythm, interval, text, etc., and generates retrieval data consisting of those rhythm, interval, text, etc. Then a music retrieval part 206 performs retrieval from the source music data base on the basis of the retrieval data and various information on numbers, composers, songwriters, singer's names, texts, etc., similar to the retrieval data are shown as a retrieval result to the user.

Docket # <u>S&ZFH020501</u>

Applic. #_____

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